Quiz 2 Solutions

1. When dielectric material is present between the plates of a parallel plate capacitor, the capacitance C is

$$C = \varepsilon_o \frac{KA}{d}$$

$$A = 2500\ cm^2 \times \left(\frac{1\ m}{100\ cm}\right)^2 = 0.25\ m^2$$

$$d = 1.0\ mm \times \frac{1\ m}{1000\ mm} = 1.0 \times 10^{-3}\ m$$

$K = 1$ (note that when $K=1$, $C = \varepsilon_o \frac{A}{d}$ as we did in the homework)

$$\varepsilon_o = \frac{1}{4\pi K_e} = 8.85 \times 10^{-12}\ \frac{C^2}{Nm^2}$$

$$C = \left(8.85 \times 10^{-12}\ \frac{C^2}{Nm^2}\right) \frac{(1)(0.25\ m^2)}{(1.0 \times 10^{-3}\ m)}$$

$$\boxed{C = 2.2 \times 10^{-9}\ F}$$

Quiz 2 Solutions

2. For a parallel plate capacitor, as in #1, $C = \varepsilon_0 \frac{KA}{d}$. Keeping all other things the same, if $A_{new} = 4A$,

$$C_{new} = \varepsilon_0 \frac{K(4A)}{d}$$

$$= 4\, \varepsilon_0 \frac{KA}{d}$$

$$= 4\, C_{original}$$

$\boxed{\text{capacitance quadruples}}$

Quiz 2 Solutions

3. Here we use the definition of capacitance

$$C \equiv \frac{Q}{\Delta V}$$

where ΔV is the potential difference between the two plates, Q is the charge on one of the plates (the other plate has charge $-Q$) and C is the capacitance. When connected to a battery directly, ΔV between the capacitor plates equals the voltage of the battery when the system is in equilibrium.

$$C = 2.5 \times 10^{-6} \text{ F}$$

$$\Delta V = 25 \text{ V}$$

$$Q = (2.5 \times 10^{-6} \text{ F})(25 \text{ V})$$

$$\boxed{Q = 6.3 \times 10^{-5} \text{ C}}$$

Quiz 2 Solutions

4. Charged particles accelerate, gaining kinetic energy and losing potential energy, as they move in an electric field when starting from rest. Negatively charged particles move opposite to the direction of the field, positively charged particles move in the field direction.

$$\boxed{\text{The particle accelerates to the left, gaining kinetic but losing potential energy.}}$$

Quiz 2 Solutions

5. Gauss' law relates the electric field outside some surface we choose to the amount of charge inside that surface. If we choose a surface such that $\vec{E}$ is the same everywhere on the surface,

$$EA = \frac{q_{enclosed}}{\varepsilon_o}$$

where A is the surface area of our chosen surface. Since $\vec{E}$ here points radially out, $\vec{E}$ is the same on the surface of a sphere of radius 0.1m that we are told about. Applying Gauss' law,

$$q_{enclosed} = \varepsilon_o E A$$

$$= (8.85\times10^{-12}\ \tfrac{C^2}{Nm^2})(4.5\ \tfrac{V}{m})[4\pi(0.1m)^2]$$

$$\boxed{q_{enclosed} = 5.0\times 10^{-12}\ C}$$

Quiz 2 Solutions

6.

We start by finding the change in potential between $x=\infty$ and $x=1.0\ \mu m$ due to the charge at $x=0$.

$$\Delta V = V_f - V_i$$

If $V=0$ for charges at ∞,

$$V = \frac{k_e q}{r}.$$

$$V_f = \frac{k_e q_{\text{charge at } 0}}{r_{\text{btwn 0 and 1}\,\mu m}}$$

$V_i =$ [redacted] 0

Relate ΔV to ΔPE:

$$\Delta V = \frac{\Delta PE}{q}$$

Since we are moving the second e^- in the potential caused by the origin e^-, we use the second e^- for q.

Now relate ΔPE to work: $W = \Delta PE$.

Quiz 2 Solutions

(6.)

$$W = \Delta PE$$

$$= q_2 \Delta V$$

$$= q_2 (V_f - V_i)$$

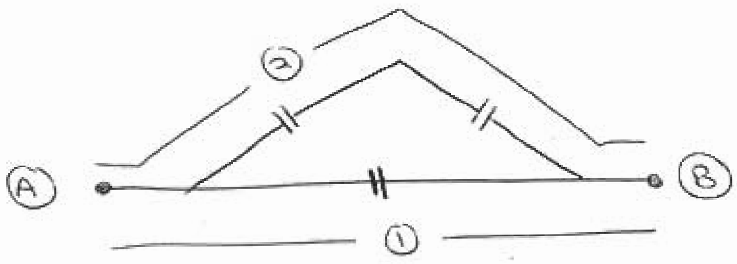
$$= q_2 \left(\frac{K_e q_1}{r_{\text{btwn } 2 \& 1}} \right)$$

$$= \frac{(8.99 \times 10^9 \text{ Nm}^2/\text{C}^2)(1.60 \times 10^{-19} \text{ C})(1.60 \times 10^{-19} \text{ C})}{(1 \times 10^{-6} \text{ m})}$$

$$\boxed{W = 2.3 \times 10^{-22} \text{ J}}$$

Quiz 2 Solutions

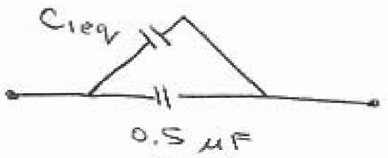
7. A moving charge has two choices to get from (A) to (B)



Therefore, if a charge chooses path 2, it must go through both capacitors. There_fore these add in series

$$\frac{1}{C_{1eq}} = \frac{1}{1.0\,\mu F} + \frac{1}{1.0\,\mu F}$$

$$C_{1eq} = 0.50\ \mu F$$



These resistors are in parallel, so

$$C_{eq} = C_{1eq} + 0.5\ \mu F$$

$$\boxed{C_{eq} = 1.0\,\mu F}$$